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(54) **Waste gas washing and analysis apparatus**

(57) The gas analysis apparatus is supplied with a sample gas by a gas sampling device (5). The sample gas is sucked into an ejector (3) in which it is mixed with washing water from a tank (1) and the resultant gas/water mixture is supplied to a water separator (7). The water separator (7) separates the water, together with any dust and corrosive soluble substances, from the gas, and supplies the purified sample gas to a gas analyser (10). The sample gas from the analyser (10), as well as gas which has bypassed the analyser (10) by way of the line (15), is fed back to the tank (1) for the purpose of balancing the concentration of dissolved gases in the water supplied to the ejector (3) with the concentration of the sample gas.

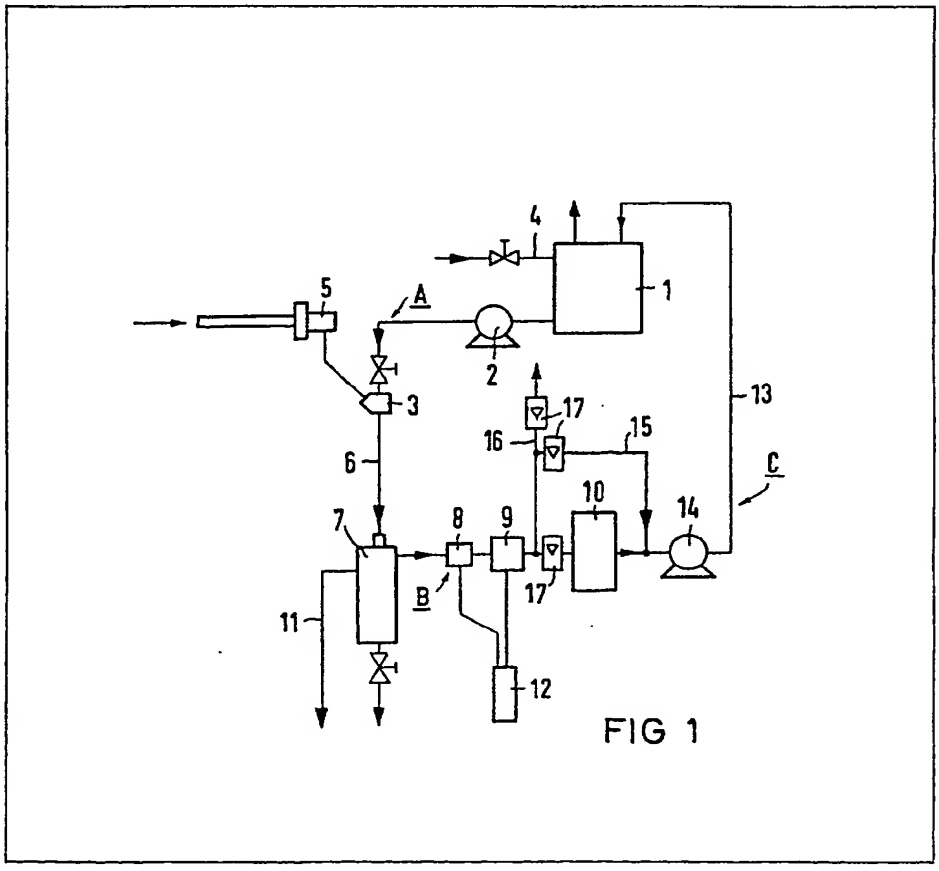

FIG 1

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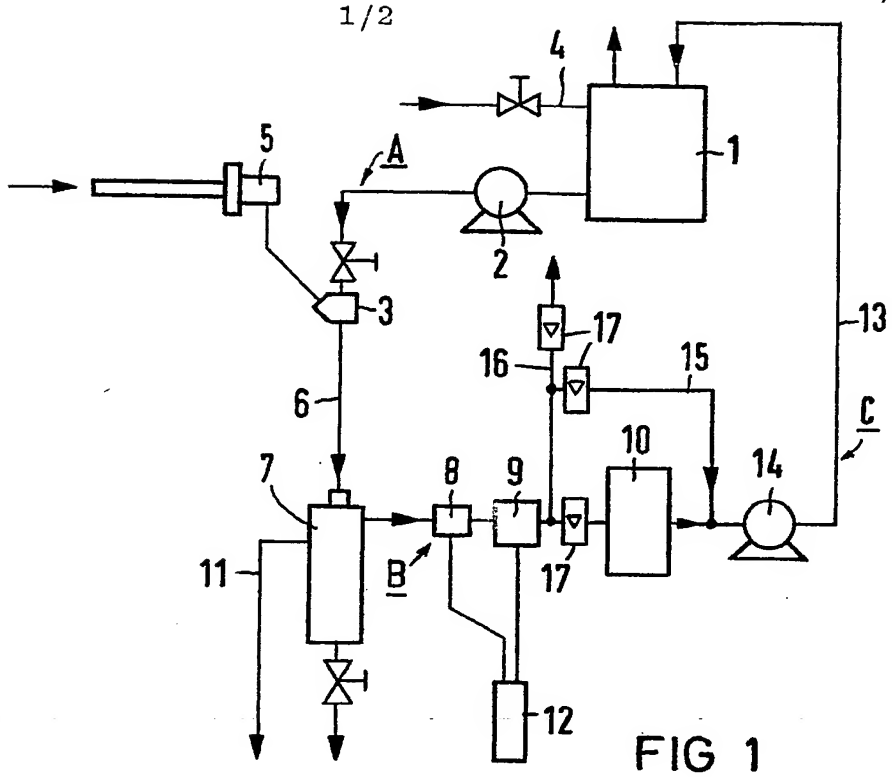
4
5
A
1
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3
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17
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15
6
C
10
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14
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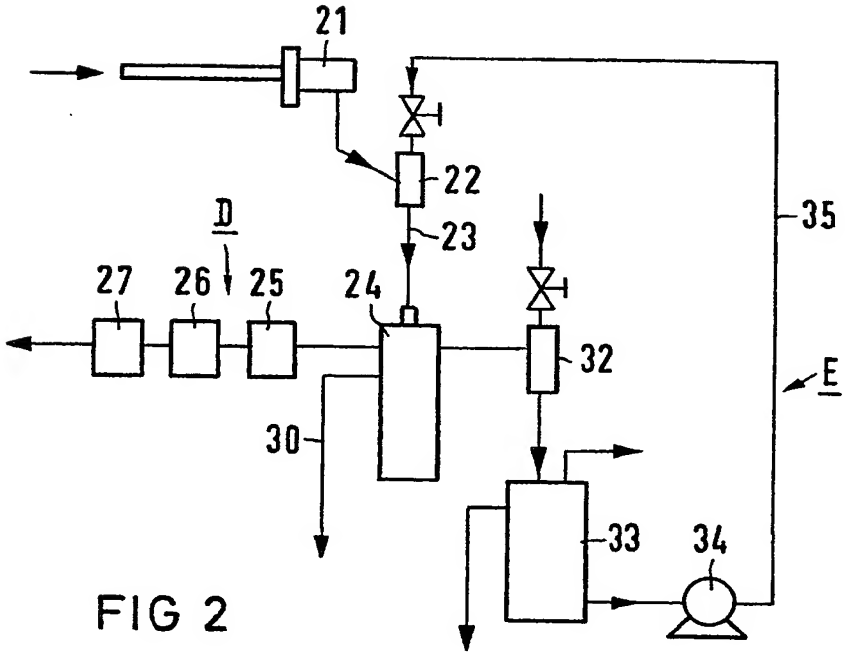
B
17
12

FIG 1


21
22
D
23
35
27
26
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E
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33
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FIG 2

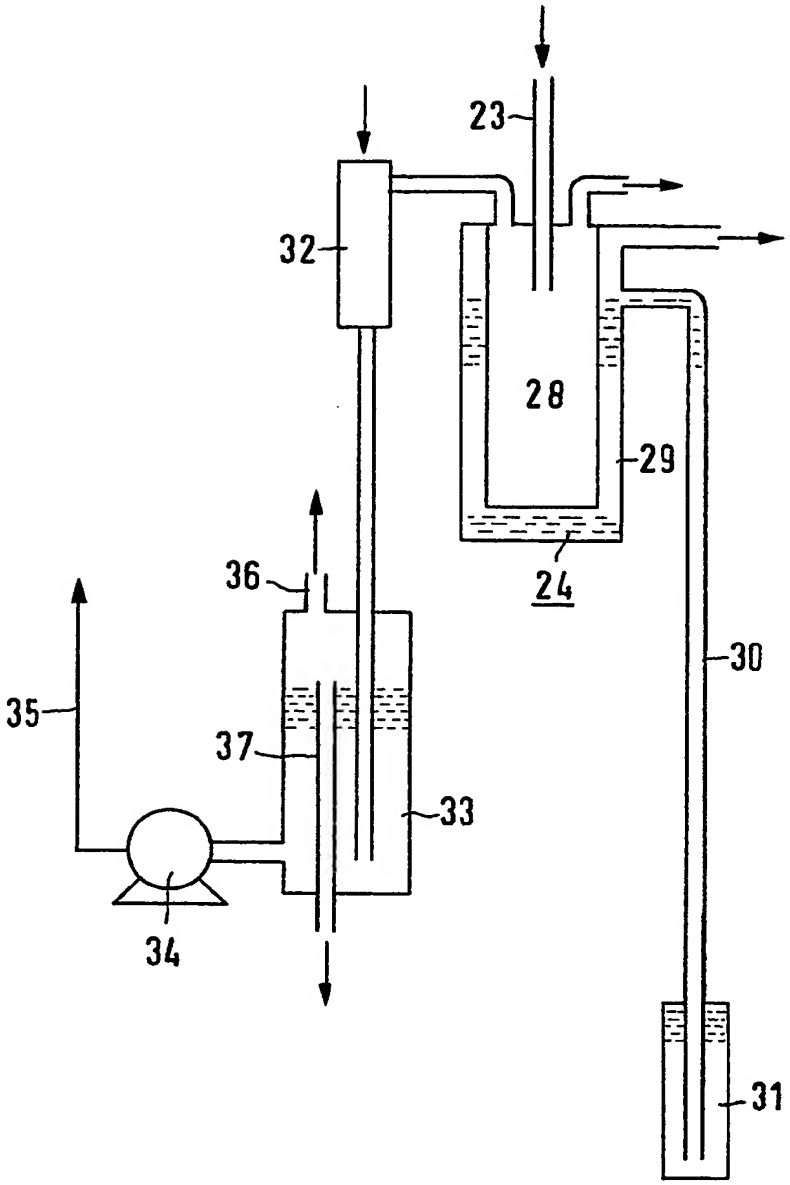

FIG 3

SPECIFICATION

Gas-analysis apparatus

This invention relates to gas analysis apparatus, more particularly, but not exclusively, for use in waste gas sampling systems.

According to the present invention, there is provided gas analysis apparatus comprising:

a) an ejector for mixing the sample gas with washing liquid;

b) a gas/liquid separator for separating the sample gas from the ejector from the washing liquid;

c) a gas analyser for analysing the sample gas from the separator; and

d) gas concentration balancing means for mixing the sample gas from the separator and/or the analyser with washing liquid to balance the concentration of dissolved gases in the washing liquid with the concentration of the sample gas, and for supplying the washing liquid having a balanced gas concentration to said ejector.

In one embodiment of the invention, the gas concentration balancing means includes a washing liquid tank within which the sample gas is intended to be mixed with the washing liquid before being discharged from the tank. In one form of this embodiment, the gas concentration balancing means is coupled to the output of the analyser, so as to receive sample gas only from the analyser. In another form, the gas concentration balancing means is coupled to the separator by a line which bypasses the analyser, so as to receive sample gas only from the separator. In a third form, the gas concentration balancing means is coupled both to the output of the analyser and to the separator by a line which bypasses the analyser, so as to receive sample gas both from the analyser and from the separator.

In a second embodiment of the invention, the gas concentration balancing means includes a further ejector for mixing the sample gas with fresh washing liquid.

If a sample of a waste gas is supplied to a gas analyser without any pretreatment, so as to analyse the composition of the waste gas, the analyser tends to become soiled with dust, vapour and moisture from the gas or to give incorrect readings due to the presence of disturbing components in the gas. Waste gas sampling systems therefore generally comprise preliminary treatment devices for pretreating the sample gas prior to entry into the analyser. Conventionally, metallic mesh filters and paper filters are used in this preliminary treatment to remove dust from the gas. However, the necessity for frequent cleaning and replacement of the filters causes maintenance to be troublesome, and additional means is required to remove soluble corrosive components if these are contained in the gas. Another known technique to remove dust and soluble corrosive components from the gas is to use an ejector, which comprises a nozzle to which washing water is supplied to produce a high speed jet which serves to suck the sample gas through the ejector. This technique has however the disadvantage, in the case of oxygen analysis, that it increases the oxygen content of the sample gas due to release of oxygen dissolved in the washing water, and, in the case of CO_2 analysis, that it decreases the CO_2 content of the sample gas due to dissolving of CO_2 in the washing water. This leads to errors in the readings.

It has been proposed therefore to circulate the washing water within the system with the object of obtaining a balance between the concentration of dissolved gases in the washing water and the concentration of the sample gas. However, this can give rise to contamination of the washing water with dust. Also, sulphur oxides (SO_2, SO_3, etc.) from the sample gas can become dissolved in the washing water, causing an increased pH of the washing water and therefore an increased corrosion effect. This results in an increased cost for the provision of corrosion-resistant materials for parts of the system, such as washing tanks, washing ejectors, conduits, water separators and pumps.

In order that the present invention may be more fully understood, two embodiments of gas analysis apparatus according to the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a block diagram of the first embodiment;

Figure 2 is a block diagram of the second embodiment, and

Figure 3 is a more detailed diagram of part of the second embodiment.

Referring first to Figure 1, the gas analysis apparatus illustrated therein comprises basically a washing water supply system A, a sample gas feed system B and a gas feed system C for gas concentration balancing. The washing water supply system A comprises a washing water tank 1, a water pump 2 and a washing ejector 3, connected in series. The washing water tank 1 is supplied with fresh washing water by water supply means 4. Reference numeral 5 denotes a gas sampling device, by means of which a sample of waste gas is taken into the apparatus as the sample gas. The sample gas is sucked into the washing ejector 3 where it is forced to mix with washing water.

The sample gas feed system B comprises a gas feed conduit 6, a water separator 7, a filter 8, a moisture separator 9 and a gas analyser 10, connected in series. The water separator 7 serves to separate washing water from the sample gas, the separated washing water being discharged through a drain pipe 11 to a discharge seal pot (not shown). The sample gas which is supplied to the gas analyser 10 by way of the filter 8 and moisture separator 9 has therefore had dust, moisture or soluble corrosive substances removed therefrom with the washing water. Water removed from the sample gas in the filter 8 and the moisture separator 9 is conducted to a drain pot 12.

The gas feed system C for gas concentration balancing comprises a gas pump 14 and a feedback conduit 13 connected between the outlet of the gas analyser 10 and the washing water tank 1. A bypass line 15 is connected across the gas analyser 10 between the moisture separator 9 and the gas pump 14.

A discharge pipe 16 branches off from the bypass line 15. A number of flowmeters 17 are disposed in the pipe lines.

In operation, waste gas is taken in as the sample gas through the sampling device 5, mixes with the washing water supplied from the washing water tank 1 through the water pump 2 to the nozzle of the washing ejector 3, and is then conducted to the water separator 7. The washing water and the sample gas are separated from each other in the water separator 7, after which the washing water is discharged through the drain pipe 11, while the clean sample gas is fed through the filter 8 and the moisture separator 9. Part of the sample gas emerging from the moisture separator 9 is supplied to the gas analyser 10, to be subject to analysis of the gas components. The remaining part of the sample gas emerging from the moisture separator 9 flows through the bypass line 15 and is supplied by way of the gas pump 14 and the conduit 13 to the washing water tank 1, to mingle with, and contact, the water in the tank before being discharged from the tank. In consequence, air dissolved in the fresh water supply is removed from the water in the tank 1 to the extent where a balance between the concentration of dissolved gas in the water and the concentration of the sample gas is obtained.

In order to maintain the sample gas pressure in the gas analyser 10 substantially identical with the atmospheric pressure, it is preferably for rather a large quantity of clean sample gas to flow in the bypass line 15.

Since the sample gas, after removal of dust, vapour and soluble corrosive substances, is fed to the washing water tank 1 supplied with fresh water and serves to obtain a balance between the concentration of dissolved gas in the water and the concentration of the sample gas before the water is supplied to the nozzle of the washing ejector 3 to suck the sample gas from the sampling device 5, the apparatus reduces measurement errors due to release of dissolved oxygen from the washing water or due to dissolving of gases in the washing water. Furthermore the cost of the apparatus is reduced, since the washing water has substantially no corrosive effect.

In a modification of the embodiment of Figure 1, the bypass line 15 is eliminated and only the sample gas discharged from the analyser 10 is fed into the washing water tank 1.

Referring now to Figure 2, the second embodiment comprises basically a sample gas supply system D and a washing water supply system E. The sample gas supply system D is coupled to a gas sampling device 21, by means of which a sample of waste gas is taken into the apparatus as the sample gas. The sample gas is sucked into a first washing ejector 22 where it is mixed with washing water supplied from the washing water supply system E. The sample gas supply system D further comprises a conduit 23, a water separator 24, a filter 25, a moisture separator 26 and a gas analyser 27, connected in series. The water separator 24 has a gas chamber 28 and a water chamber 29, as shown in Figure 3. The washing water is separated from the sample gas in the gas chamber 28 and passes into the water chamber 29. The washing water is then discharged through a drain pipe 30 to a discharge seal pot 31.

The washing water supply system E comprises a second washing ejector 32 which is supplied with fresh water from a water supply. The outlet of the second washing ejector 32 is coupled to the nozzle of the first washing ejector 22 by way of a washing water tank 33, a water pump 34 and a supply conduit 35, connected in series. The washing water tank 33 is, as shown in Figure 3, provided with a gas vent 36 at its top and an overflow pipe 37 so positioned as to form a vacant space at the top of the tank.

In operation, waste gas is taken in as the sample gas through the sampling device 21, forced to mix with the washing water fed from the washing water supply system E to the nozzle of the first washing ejector 22, and then conducted through the conduit 23 to the gas chamber 28 of the water separator 24. After gas/water separation in the gas chamber 28, the washing water passes into the water chamber 29 and is then discharged through the drain pipe 30 to the discharge seal pot 31, while sample gas free of dust is supplied through the filter 25 and the moisture separator 26 to the gas analyser 27, to be subject to analysis of the gas components. Fresh water from the water supply is then supplied to the nozzle of the second washing ejector 32 to suck further sample gas from the water separator 24. The gas/water mixture emitted by the second washing ejector 32 is conducted to the washing water tank 33. In the course of this process, a balance is obtained between the concentration of dissolved gas in the water and the concentration of the sample gas. The sample gas is then released through the gas vent 36, and the washing water is fed *via* the water pump 34 and the conduit 35 to the nozzle of the first washing ejector 22.

In a modification of the second embodiment, the first washing ejector 22, the water separator 24 and the second washing ejector 32 form a unitary assembly.

Since the sample gas, after removal of dust, vapour and soluble corrosive substances, is subjected to a second gas/water mixing in the second washing ejector 32 to obtain a balance between the concentration of dissolved gas in the water and the concentration of the sample gas before the washing water is supplied to the nozzle of the first washing ejector 22, the second embodiment reduces measurement errors due to release of dissolved oxygen from the washing water or due to dissolving of gases in the washing water. Furthermore, there is no recirculation of washing water in a closed loop, but fresh supply of washing water into the apparatus takes place by was of the second washing ejector 32. This dispenses with the requirement for corrosion-resistant equipment, and low cost equipment and maintenance are therefore obtained.

CLAIMS

1. Gas analysis apparatus comprising:

a) an ejector for mixing the sample gas with washing liquid;

b) a gas/liquid separator for separating the sam-

ple gas from the ejector from the washing liquid;

c)a gas analyser for analysing the sample gas from the separator; and

d) gas concentration balancing means for mixing the sample gas from the separator and/or the analyser with washing liquid to balance the concentration of dissolved gases in the washing liquid with the concentration of the sample gas, and for supplying the washing liquid having a balanced gas concentration to said ejector.

2. Apparatus according to claim 1, wherein the gas concentration balancing means includes a washing liquid tank within which the sample gas is intended to be mixed with the washing liquid before being discharged from the tank.

3. Apparatus according to claim 2, wherein the gas concentration balancing means further includes a gas pump for supplying sample gas from the separator and/or the analyser to the tank.

4. Apparatus according to claim 2 or 3, wherein the gas concentration balancing means further includes a liquid pump for supplying washing liquid from the tank to said ejector.

5. Apparatus according to claim 2, 3 or 4, wherein the gas concentration balancing means further includes supply means for supplying fresh washing liquid to the tank.

6. Apparatus according to any one of claims 1 to 5, wherein the gas concentration balancing means is coupled to the output of the analyser, so as to receive sample gas only from the analyser.

7. Apparatus according to any one of claims 1 to 5, wherein the gas concentration balancing means is coupled to the separator by a line which bypasses the analyser, so as to receive sample gas only from the separator.

8. Apparatus according to any one of claims 1 to 5, wherein the gas concentration balancing means is coupled both to the output of the analyser and to the separator by a line which bypasses the analyser, so as to receive sample gas both from the analyser and from the separator.

9. Apparatus according to claim 1, wherein the gas concentration balancing means includes a further ejector for mixing the sample gas with fresh washing liquid.

10. Apparatus according to claim 9, wherein the gas concentration balancing means further includes separating means for separating the washing liquid from the sample gas and for supplying the washing liquid to the first-mentioned ejector.

11. Apparatus according to claim 10, wherein the separating means comprises a vented tank and a pump.

12. Apparatus according to claim 9, 10 or 11, wherein the ejectors and the separator form a unitary assembly.

13. Apparatus according to any preceding claim, adapted for use with water as the washing liquid.

14. Gas analysis apparatus substantially as hereinbefore described with reference to, and/or as illustrated in, Figure 1 of the accompanying drawings.

15. Gas analysis apparatus substantially as hereinbefore described with reference to, and/or as illustrated in, Figures 2 and 3 of the accompanying drawings.

16. The combination of gas analysis apparatus according to any preceding claim and a gas sampling device.

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